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Exploring Pathways to Link Agrobiodiversity and Human Health

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Abstract

Growing evidence indicates that the overall reduction of biodiversity in agricultural systems is concomitant to dietary simplification and related health effects, yet our understanding of the complex relationship between agrobiodiversity and health is still poor. This chapter explores pathways that could mediate this relationship at the local level. It begins by revisiting the definition of agrobiodiversity to disentangle its social components. In addition, the concept of health is broadened from the physical perspective. Pathways are then explored to link agrobiodiversity with physical health (diet, nutrition, and beyond) and mental health, including considerations of how food culture and traditional agrobiodiversity management knowledge contribute to identity and self-esteem. Discussion follows on the social aspects related to the production and consumption of agrobiodiversity that promote health and well-being. In conclusion, the chapter contextualizes how issues addressed at the local level fit within a broader political context.

Introduction

The twentieth century witnessed a drastic reduction of biodiversity in many agricultural production systems (i.e., agroforestry, home gardens, shifting agriculture), a change concomitant with the industrialization of agriculture and the expansion of monocultures that affected individual productive units (i.e., farms) as well as the broad agricultural landscape (Thrupp 2000). Such changes in the agricultural system, while not novel, intensified during the last century as the direct result of policy measures aimed at "feeding the world," in line with a productivist approach to agriculture, which prioritized crop yield increase over crop diversity maintenance (Chapter 6). Moreover, such changes were generally imposed on farmers, following a top-down approach to agricultural decision

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making and, in many areas of the developing world, promoting the introduction of cash crops, with consequent losses in food sovereignty (Friedmann and McMichael 1989).

Changes in the agricultural production system appear to have had unexpected effects on human health. For example, agricultural simplification seems to be connected to dietary simplification (i.e., the global trend in increasing the consumption of cereals parallels the global trend in decreasing the intake of pulses, legumes, and traditional grains or wild green leafy vegetables) (Khoury et al. 2014). These changes, in turn, have been associated with an increase in malnutrition (i.e., stunting, anemia, micronutrient deficiencies, overweight) and related health effects (Frison et al. 2006, 2011; Powell et al. 2015; Vincenti et al. 2008). Thus, agreement has grown that loss of agrobiodiversity matters, not only in itself, but because of its effects on human health (Johns and Eyzaguirre 2006; Kahane et al. 2013).

Despite growing evidence of linkages between an overall reduction of biodiversity in agricultural production systems and dietary simplification, our scientific understanding of the complex relationship between agrobiodiversity and health is still poor. While it is highly plausible that there is a causal link leading from the reduction of agrobiodiversity to health problems through diet simplification, empirical evidence showing this connection is scarce (Powell et al. 2015). Providing evidence on the direction of causality is important because, without it, we cannot rule out that both phenomena are only correlated (i.e., they occur at the same time) or that they are both caused by a third factor, such as abandonment of traditional livelihoods. In addition, beyond nutrition, there could be other pathways through which agrobiodiversity could relate to health. For example, some research has shown that diversified landscape elements, such as gardens, are associated with better human well-being (Litt et al. 2011; Milligan et al. 2004). So, a potential pathway between agrobiodiversity and health—albeit one that is largely unexplored—could be through the satisfaction of cultural ecosystem services associated with diversified landscapes (Calvet-Mir et al. 2012b).

In this chapter, we discuss the potential pathways through which agrobiodiversity can be related to human health. Our exploration focuses on the local level: pathways that might relate to effects on individuals, households, communities, or local landscapes (i.e., landscapes managed by closely linked communities). We have chosen this level of analysis because many decisions regarding agricultural production and dietary or other health-related choices occur at the local level. Afterward, we discuss how the local scale is connected to processes at larger scales through agricultural and health policies. Figure 11.1 provides a graphical representation of the hypothesized connections between agrobiodiversity and health. As many ideas in this chapter are new, they are not yet supported by empirical research. Our intent has not been to provide a review of existing findings but rather to spur future research on the linkages between agrobiodiversity and human health.

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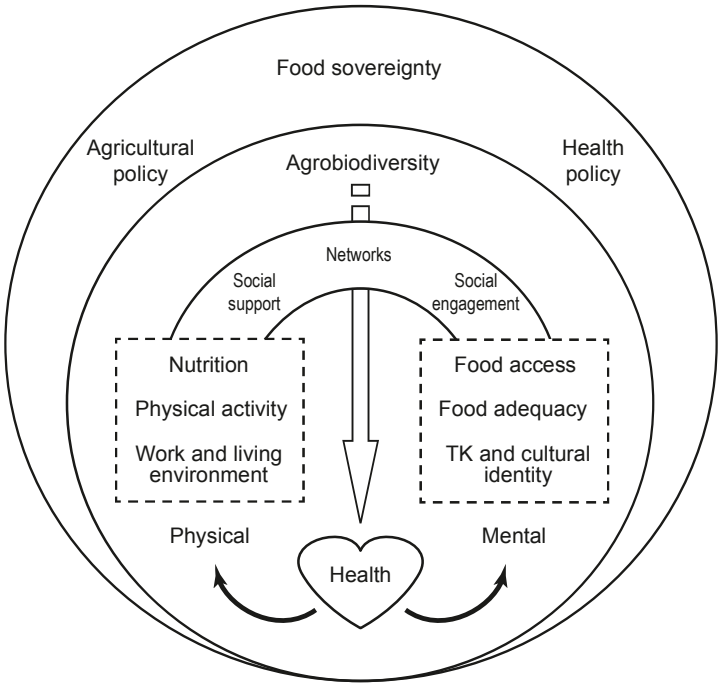

Figure 11.1 Potential pathways linking agrobiodiversity and health. TK: traditional knowledge.

Revisiting the Definitions of Agrobiodiversity and Health

The focus of this chapter requires us to revisit the definitions of agrobiodiversity and health carefully. The Food and Agricultural Organization (FAO 1999a:5) defines agrobiodiversity as

> the variety and variability of animals, plants, and microorganisms that are used directly or indirectly for food and agriculture production, including crops, livestock, forestry, and fisheries. It comprises the diversity of genetic resources (varieties and breeds) and species used as food, fodder, fiber, fuel, and pharmaceuticals. It also includes the diversity of nonharvested species that support agricultural production (soil microorganisms, predators, pollinators), and those in the wider environment that support agroecosystems (agricultural, pastoral, forest, and aquatic) as well as the diversity of the agroecosystems.

This definition rests on the fundamental idea that agrobiodiversity entails human management of natural resources (i.e., species, land, water, insects, and biota) to produce food and to satisfy other human needs. Consequently, the study of agrobiodiversity requires assessing not only the diversity of species in the system, but how they are managed and how both species diversity and

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management practices are embedded within cultural structures, institutions, and social relations that allow for the production, distribution, and consumption of food species as well as the transmission of knowledge regarding the properties, the material and symbolic uses, and culturally adequate ways to cultivate, use, and consume such agrobiodiversity (Powell et al. 2015). Moreover, the study of local agrobiodiversity also requires examining the influences of social institutions and cultural factors operating at larger scales (e.g., national and international policy decisions) that frame the management of systems enhancing or constraining agrobiodiversity (Johns et al. 2013). For a more inclusive definition of agrobiodiversity, see Zimmerer et al. (Chapter 1).

Taking a holistic approach, the World Health Organization (WHO) has defined health as "the state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity" (WHO 1946). In its attempt to contextualize health, WHO also highlights that factors such as the social (i.e., being connected to others), the economic (i.e., income and employment), and the physical (i.e., access to safe water and clean air) environments are as important as a person's individual characteristics (i.e., genetics) and behaviors (i.e., diet or exercise) in determining health. Under the umbrella of WHO's holistic approach to health, researchers have analyzed, for example, the physical and mental health consequences of social aspects, such as income inequality (Diener and Seligman 2004; Wilkinson 2000), contact with nature (Milligan et al. 2004; Shillington 2008), belonging to meaningful social networks (Perkins et al. 2015), or adherence to specific cultural models (Dressler and Bindon 2000).

One of the main insights from this research is that health is best understood as a multidimensional state that is socially mediated and manifested through physical and mental well-being. Defining health as a multidimensional concept allows for a broader exploration of the potential relations between agrobiodiversity and health. If health has many dimensions, the pathways to health are likely multiple and probably intermingled in a complex web that challenges the "quick technical fix" approach to protecting or improving health—one that calls for a more comprehensive exploration of the complex relations between agrobiodiversity and the multiple dimensions of health.

Pathways between Agrobiodiversity and Physical Health

Most research examining the links between agrobiodiversity and health has focused on how agrobiodiversity relates to physical health through diet and nutrition (see Chapters 9 and 10). In connecting overall agricultural simplification and reduced dietary diversity, a major finding has been that even under adequate caloric intake, the reduction of dietary diversity might lead to "hidden hunger" or micronutrient deficiencies (Kahane et al. 2013), with pervasive consequences in physical health (i.e., immunostimulation or the worsening of

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preexisting health conditions) (Johns et al. 2013; Vincenti et al. 2008). Dietary changes have also been associated with an increase in malnutrition (i.e., stunting, anemia, undernourishment, obesity) and related health effects (Frison et al. 2006b, 2011; Powell et al. 2015; Vincenti et al. 2008).

In this context, and partly as a reaction to mainstream efforts to address micronutrient deficiencies through fortification (e.g., iodine in salt), supplements (i.e., high doses of vitamin A) or biofortification (i.e., increasing staple crops' micronutrient content), some researchers have argued that enhancing agrobiodiversity in systems could be an adequate approach to prevent "hidden hunger" and related health effects (Frison et al. 2011; Powell et al. 2015; Ruel 2003). The increase of species and varietal diversity in a system's agrobiodiversity is assumed to increase dietary diversity, which would not only provide adequate micronutrients but also boost the ingestion of foods containing phytochemicals with discrete bioactivities toward human biochemistry and metabolism, or nutraceutical foods (Carlos et al. 2007; Dillard and German 2000). Research suggests that the ingestion of a diversity of phytochemicals contained in cultivated and noncultivated plants—characteristics of local culinary traditions from agrobiodiverse-rich systems—enhances physical health (Heinrich et al. 2005; Pieroni et al. 2005), although variations should be expected across case studies.

While the benefits of a diversified diet continue to be productively examined, we still lack the empirical research to link agrobiodiversity and dietary diversity (and therefore nutrition and health) at the local level. According to recent reviews (e.g., Powell et al. 2015), relatively few empirical studies have tested the links between on-farm agricultural diversity and diversified household dietary choices (e.g., Jones et al. 2014), and not all of them report a positive association. Furthermore, the effect of intraspecific diversity has not yet been thoroughly explored. The weak evidence that has been found to link agrobiodiversity and dietary diversity has theoretical and methodological explanations.

At a theoretical level, many confounding factors (other than on-farm agrobiodiversity) shape dietary choices of households. For example, even most self-sufficient households participate in markets, either by supplying labor or by acquiring agricultural inputs or foods, a situation that certainly might affect producers' dietary choices in both directions (i.e., facilitating access to both nutritious and nonnutritious foods and beverages).

At a methodological level, authors have argued that research on the topic needs to be methodologically stronger, including long-term data and rigorous monitoring through impact evaluations (Jaenicke and Virchow 2013). The field also needs to develop proxies of dietary diversity that can be better matched with proxies of agrobiodiversity; at the moment they both use different taxonomies. Dietary diversity is often measured through intake of species in a set of food groups (i.e., at the species level). Agrobiodiversity, however, includes other levels above (i.e., landscape) and below (i.e., varietal diversity)

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the species level. The development of a taxonomy that allows correlations to be drawn is a prerequisite to exploring potential links between the various levels at which agrobiodiversity and health can be measured.

Beyond nutrition, there are many other potential pathways through which agrobiodiversity might relate to physical health. For instance, the maintenance of high yields in simplified agricultural systems generally requires the use of external inputs with proven detrimental effects on the environment (e.g., air, water, soil, biodiversity) and physical health of individuals (Lang and Heasman 2004). The use of pesticides constitutes a major health problem, causing death, acute and chronic neurotoxicity, lung damage, chemical burns, infant methemoglobinemia (caused by ingestion of nitrates in drinking water), various cancers, immunological abnormalities, as well as adverse reproductive and developmental effects (Eddleston et al. 2002; Weisenburger 1993). Because agricultural systems which aim to enhance agrobiodiversity generally do not heavily rely on such external inputs as pesticides (Altieri et al. 2012), they might directly contribute to physical health by reducing producers' exposure to agrochemicals. Such an impact, moreover, could extend beyond the farmer's level and reach the whole society, as has been shown in research associating the use of antibiotics in livestock farming and the increase in antibiotic resistance among bacterial pathogens (Mathew et al. 2007; Shea 2003).

Agrobiodiversity-rich systems might also contribute indirectly to physical health because of their overall positive environmental impact. It has been argued that the physical environment in which a person lives is an important determinant of health: access to clean water, sanitation, and diverse productive ecosystems has a positive impact on health and well-being (Pinstrup-Andersen 2009; Schmidhuber and Tubiello 2007). It has also been shown that industrial agriculture exerts an enormous environmental impact: emissions of greenhouse gases contributing to climate change, land-use change leading to deforestation, salinization of soils due to over irrigation, and water and land pollution from nitrogen and phosphorous fertilizers (Tilman 1999; see also Chapters 7 and 8). So, one could argue that agricultural systems that have lower environmental impacts, such as sustainable agrobiodiverse systems (Altieri et al. 2012), might positively impact physical health through the promotion of healthier environments. However, just as it is true that agrobiodiversity-rich systems are not always managed in an environmentally sound manner, monocultures do not always leave highly detrimental environmental footprints (i.e., cultivated pastures). This makes it reasonable to argue that more research is needed to elucidate the conditions under which positive health effects of environmentally managed agroecosystems can be expected.

Finally, another potential pathway that links agrobiodiversity to physical health is physical activity. The management of diversified landscapes—which include a diversity of crops (i.e., minor grains, pulses, fruits, vegetables, and root and tuber crops in addition to common staple crops) with different management techniques and various requirements at different points of time—might

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require greater physical effort than the management of more simplified agricultural systems, which are easier to mechanize (although this might not always be the case). Higher physical effort maintained throughout the year might, in turn, affect physical health. Research into the health impacts of gardening, for instance, has reported benefits to physical health, especially among the elderly (Litt et al. 2011). Since this study, however, assessed the impact of leisure gardening in a sample of people new to gardening, results are not easily generalizable to the continuous management of larger agroecological units. Nevertheless, future research could replicate the approach to compare farmers managing farms with different levels of agrobiodiversity. Again, we note that the relationship can go both ways: manually managing farms with high agrobiodiversity could promote a healthy level of physical activity, but such activity could also create a work overload with negative health effects. Moreover, health effects from an increased workload could vary across groups (e.g., women, children, men). Research is needed to identify the conditions under which positive health effects of physical activity associated with the management of agrobiodiverse systems can be expected.

Pathways between Agrobiodiversity and Mental Health

WHO defines mental health as the state of well-being in which an "individual realizes his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to her or his community." Anxiety, depression, and stress are common mental health disorders. Are there any links between agrobiodiversity and mental health? The answer is: we mostly do not know. Research on this the topic is largely nonexistent, perhaps because of important methodological challenges not only in measuring a potential link between agrobiodiversity and mental health, but also in attributing a causal link to the relation. Although empirical research on the topic is largely nonexistent, we propose that there are potential links worth exploring. Some of the links explored below might not be exclusive to agrobiodiversity-rich systems; they could also be explored in many other agricultural systems (e.g., urban gardens). Thus, empirical research is needed to determine whether the proposed links exist and manifest differently in agricultural systems with varying levels of agrobiodiversity.

Perhaps the most important link between agrobiodiversity and mental health relates to feelings associated with access (or lack of access) to sufficient food, to food that is considered culturally adequate, and to culturally acceptable productive landscapes. Using the FAO's concept of food security as the continuous and affordable access to nutritious, culturally appropriate foods (FAO 1996), researchers working in urban and rural settings have established a causal relation between food insecurity and mental morbidity, including anxiety and depression. This research shows that people who experience

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food insecurity, especially pregnant women or women with young children, are more likely to report depressive episodes or anxiety disorders (Hadley and Patil 2006; Whitaker et al. 2006). As it has been argued, if agrobiodiversity-rich systems are more able to ensure food security at the household level by providing continuous access to local foods, then agrobiodiversity-rich systems could help protect mental health by reducing the stress caused by situations of food insecurity.

Furthermore, there are reasons to think that the lack of access to food considered culturally adequate can affect mental health in the same way that lack of access to sufficient food does. Dietary choices are deeply embedded within cultures and ways of living; they are a function of different socioeconomic processes that range from culture to class, income, age, or profession (Greenberg 2003; Kuhnlein et al. 1996; Noack and Pouw 2015). In this sense, it has been argued that communities that value their traditional food systems—foods people know and have access to from their local environment through farming or wild harvesting (Kuhnlein et al. 2009)—are better able to conserve local food specialties and the associated agrobiodiversity (Chapter 12). Moreover, these communities exhibit a lower prevalence of diet-related chronic diseases (Johns et al. 2013). Do they also show less prevalence of mental health problems associated with food insecurity? We just do not know.

Conversely, the stigmatization of dietary choices (e.g., traditional foods being considered "backward" or low in status) might generate negative feelings (i.e., shame) among those who identify with these foods (Cruz-Garcia and Howard 2013). Research shows that stigmatization affects dietary choice and that people sometimes abandon the production and consumption of stigmatized foods, even when they continue to be locally available (Bharucha and Pretty 2010; Reyes-García et al. 2015). We know that such behavior has adverse effects on nutrition, as happened with the reduction of pearl millet consumption in African countries (Johns et al. 2013). Does stigmatization also affect mental health? Again, the answer is: we do not know. Certainly, more research is needed.

The argument can be extended to include considerations related not only to the food system but also to the cultural knowledge associated with it. To a high degree, agrobiodiversity-rich systems are knowledge intensive: to maintain agrobiodiversity, complex information on species selection, combination, and management is required (Altieri et al. 2012). Consequently, the management of agrobiodiversity-rich systems is often dependent on traditional ecological knowledge, or the cumulative and evolving body of knowledge, practices, and beliefs held by communities about their relations with the ecosystems in which they are embedded (Berkes et al. 2000; Kuhnlein et al. 2009, 2013).

Traditional ecological knowledge, however, is not only essential for the creation and maintenance of biodiversity-rich cultural landscapes, it is also a cornerstone of local cultural identities (Barthel et al. 2013). Existing research shows that the loss of cultural identity is a very important determinant

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of mental health both among migrants (Mossakowski 2003; Schwartz et al. 2010) and Indigenous Peoples (Kirmayer et al. 2000; Kral et al. 2011). Does the loss of agrobiodiversity-rich systems, and the associated loss of traditional knowledge and management practices, affect the mental health of knowledge holders? Do changes in knowledge systems, dietary choices, and agrobiodiversity associated with processes of human migration (Chapter 8) relate to mental health? Future research is needed to address these issues.

We emphasize the importance of adopting a gender perspective in pursuing such lines of enquiry. Since men and women assume different roles in various agricultural production systems, they might be affected in different ways by changes. The gendered distribution of agricultural work related to the management of agroecosystems might impact the physical health of women and men disparately. The same argument could be constructed around mental health. For instance, many agrobiodiversity-rich systems are highly dependent on women's role as seed custodians (Howard 2006; Zimmerer 2003b; Zimmerer et al. 2015). The loss of agrobiodiversity-containing systems might have a differentiated gendered effect: women might suffer more, in terms of mental health, through the loss of self-esteem associated with being marginalized in decisions relative to production and income use (Ravera et al. 2019). Effects of agrobiodiversity changes on physical and mental health might be context specific, but adopting a gender perspective might elucidate patterns of differentiated effects within a single case study.

Agrobiodiversity-Based Social Networks as Pathways to Physical and Mental Health

Social network research typically characterizes the web of social relations around an individual, including those with whom a person relates and how (Smith and Christakis 2008). Despite the growing evidence that the composition and structure of social networks affect an individual's physical and mental health (Smith and Christakis 2008; Valente 2010), and despite the growing body of knowledge which highlights the importance of social networks in understanding agrobiodiversity management (Calvet-Mir et al. 2012a; Reyes-Garcia et al. 2013; Ricciardi 2015), the role of social networks in explaining the association between agrobiodiversity and health remains completely unexplored. The main argument is that social networks related to the production and consumption of agrobiodiversity (i.e., agrobiodiversity-based social networks) create pathways which propagate attitudes, behaviors, and emotions, as well as financial, physical, informational, labor, and social resources (Perkins et al. 2015) which, in turn, could affect health. Based on the work of Berkman and Glass (2000), one could hypothesize that there are four main pathways through which agrobiodiversity-based social networks might mediate an association between agrobiodiversity and health:

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- Access to resources (e.g., seeds, information; see Chapter 13)
- Social influence (e.g., spread of nutrition related behaviors)
- Social engagement
- Provision of social support (both perceived and actual)

Agrobiodiversity-based social networks may be particularly vital to health by being a *source of resources* (e.g., seeds, stems, associated knowledge), which could be critical in times of food stress or insecurity (Calvet-Mir et al. 2012a; Reyes-Garcia et al. 2013; Ricciardi 2015). Research among farmers in the Catalan Pyrenees reveals that networks of seed exchange act as human corridors to facilitate the flow of local landraces and associated knowledge (Calvet-Mir et al. 2012a). Moreover, farmers who hold positions of centrality in agrobiodiversity-based social networks are also more likely to maintain local landraces and associated knowledge (Kawa et al. 2013; Reyes-Garcia et al. 2013), acting as seed banks in case of need (Coomes et al. 2015). Therefore, because they provide access to material resources and information, agrobiodiversity-based social networks could be critical to ensure agrobiodiversity and germplasm conservation, and consequently to enhance food security (Chapters 13 and 14).

Agrobiodiversity-based social networks could also mediate the relation between agrobiodiversity and physical and mental health through *social influence*, or the spread of ideas and behaviors within and between communities (Valente 2010). Haselmair et al. (2014) have shown the importance of social networks in spreading food-related behaviors among migrants, and Zimmerer (2010) found how preferences for traditional, local dietary items spread among people who support local foods, organic agriculture, fair trade, and multifunctional agriculture, thereby reinforcing biological diversity in agriculture. Such findings suggest that social influence could mediate the spread of ideas and behaviors related to agrobiodiversity, which in turn could ultimately relate to physical and mental health outcomes through, for instance, the adoption of a more diverse and culturally accepted diet.

Another potential pathway through which agrobiodiversity might relate to health through agrobiodiversity-based social networks is *social engagement*, or one's degree of participation in a community or society (Chapter 12). The maintenance of landscape agrobiodiversity is often done through social structures and institutions that require social interactions. For example, farmers need to be embedded in a social network to exchange seeds and agricultural products: those exchanges might also confer a source of personal status and satisfaction (Hardon-Baars 2000). Similarly, the management of common resources (i.e., water, forest, pastures) requires coordination between people and has given rise to many common management systems (Ostrom 1990). Such institutions provide ample opportunities for social engagement and social activities that ultimately might promote physical and mental health (Berkman et al. 2000).

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Finally, *social support*—the perception that one is cared for, has assistance available from other people, and is part of a supportive social network—is one of the most well-documented psychosocial factors influencing physical and mental health (Berkman et al. 2000; Uchino 2009). We argue that participation in social networks of seed exchanges or other agrobiodiversity-based social networks (sometimes fostered by information communication technologies) might provide a range of supportive resources, including emotional (e.g., nurturance), tangible (e.g., seeds), informational (e.g., advice), or companionship (e.g., sense of belonging), which might ultimately relate to both physical and mental health. We know of no research that has directly addressed the linkages considered in this section and thus recommend their inclusion in future research programs.

Again, while we know of no research directly addressing those links, we consider that the different topics outlined in this section should be part of the agenda linking agrobiodiversity and health in a comprehensive way.

Strengthening the Link between Agrobiodiversity and Health: The Role of Local Decision Making and Food Sovereignty

Having explored links through which agrobiodiverse-rich systems could relate to the physical and mental health of individuals, households, communities, and local landscapes, we wish to broaden the discussion by asking:

- Is agrobiodiversity really a local choice?
- What are the elements that influence the presence or absence of agrobiodiversity-rich food systems (and its potential effects on health) at the local level?

We begin by placing the reduction of biodiversity in a historical context: in many agricultural production systems, reduction occurred as the direct result of policy measures and development paradigms that were aligned with productivist approaches, which reinforced top-down agricultural decision making (see Bonanno et al. 1995; Friedmann and McMichael 1989; McMichael 2009). Together with the spread of a neoliberal globalized food system, such measures resulted not only in agrobiodiversity loss, but in a generalized loss of local power to control and hold authority in decisions related to the food system (Otero 2012; Wolff 2004). Although some localized agricultural systems remain diversified and controlled by communities (e.g., Baker 2008; Chase Smith et al. 2013), the trend of the past century has been toward intensification and centralization of food systems (Friedmann and McMichael 1989).

In Europe, for example, after World War II, a series of centralized policy measures (included in the new Common Agricultural Policy) were designed to enhance the productivity of farms by coupling economic support with agricultural production regardless of economic, social, and ecological impacts (Gatto

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et al. 2013). In a nutshell, the new agricultural paradigm promoted high-yield crop selection, crop homogenization, and the standardization of agricultural products while removing decision-making power from the farmers through the concession of subsidies to specific crops (Wolff 2004).

For some time now, social movements created by farmers (e.g., La Via Campesina) and consumers (e.g., Slow Food) have started to claim the need to restore some level of *food sovereignty*, or the downscaling of decision making related to agricultural production and consumption to local arenas (Chapters 12 and 13). Such claims contest the neoliberal globalized food system while stressing the need to enhance local knowledge systems through farmer-to-farmer networks and the promotion of agroecological innovations and ideas (Altieri and Manuel Toledo 2011; Chapter 4). Thus, as they strive for local food sovereignty leading to food systems that are more supportive of agrobiodiversity and that can reverse the simplification and industrialization processes, many local initiatives have withdrawn from general food policy and economic trends. For instance, the growing social movement for food sovereignty in Latin America and beyond (e.g., La Via Campesina) provides an integrated approach to local agricultural decision making and farmers' empowerment that has strong links to agrobiodiverse farming and that consequently might enhance some of the local pathways to health previously discussed. In urban scenarios representing the consumer side, initiatives such as food consumption groups can also be seen as enhancing these linkages, since these groups promote shorter food chains, higher farmer bargaining power, and alternative (organic) food production systems (Chapters 8 and 15). Both of these emerging initiatives, which could also be seen as shifters of the symbolic contexts in which local decisions take place, mobilize traditional ecological knowledge and enhance agrobiodiversity, factors considered by some as drivers of agroecological transition processes (López-García and Guzmán-Casado 2013).

In summary, despite the success of many of these civil society initiatives (Renting and Wiskerke 2010), we must bear in mind that local choices—specifically those that impact health (physical and mental) and food systems (production and consumption)—do not happen in a void: local decision making interacts and is affected by policies (global, national, regional) and economic trends. Thus, if public health policies continue to be viewed in isolation, we will miss the potential role for sustainable food systems in the health of individuals and communities and fail to strengthen linkages to agrobiodiversity.

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Karl S. Zimmerer and Stef de Haan, eds. 2019. Strüngmann Forum Reports, vol. 24, series ed. Julia R. Lupp.
Cambridge, MA: MIT Press. ISBN 9780262038683.

Altieri, M. A., F. R. Funes-Monzote, and P. Petersen. 2012. Agroecologically Efficient Agricultural Systems for Smallholder Farmers: Contributions to Food Sovereignty. *Agronom. Sustain. Devel.* **32**:1–13. [11]

Altieri, M. A., and V. Manuel Toledo. 2011. The Agroecological Revolution in Latin America: Rescuing Nature, Ensuring Food Sovereignty and Empowering Peasants. *J. Peasant Stud.* **38**:587–612. [11]

Baker, L. E. 2008. Local Food Networks and Maize Agrodiversity Conservation: Two Case Studies from Mexico. *Local Environ.* **13**:235–251. [11]

Barthel, S., C. Crumley, and U. Svedin. 2013. Biocultural Refugia: Combating the Erosion of Diversity in Landscapes of Food Production. *Ecol. Soc.* **18**:71. [11]

Berkes, F., J. Colding, and C. Folke. 2000. Rediscovery of Traditional Ecological Knowledge as Adaptive Management. *Ecol. Appl.* **10**:1251–1262. [11]

Berkman, L. F., and T. Glass. 2000. Social Integration, Social Networks, Social Support, and Health. In: Social Epidemiology, ed. L. F. Berkman and I. Kawachi, pp. 137–153. New York: Oxford University Press. [11]

Berkman, L. F., T. Glass, I. Brissette, and T. E. Seeman. 2000. From Social Integration to Health: Durkheim in the New Millenium. *Soc. Sci. Med.* **51**:843–867. [11]

Bharucha, Z., and J. Pretty. 2010. The Roles and Values of Wild Foods in Agricultural Systems. *Philosophical Transactions of the Royal Society B-Biological Sciences* **365**:2913–2926. [11]

Bonanno, A., D. Constance, and M. Hendrickson. 1995. Global Agrofood Corporations and the State: The Ferruzzi Case. *Rural Sociol.* **60**:274–296. [11]

Calvet-Mir, L., M. Calvet-Mir, J. L. Molina, and V. Reyes-Garcia. 2012a. Seeds Exchange as an Agrobiodiversity Conservation Mechanism: A Case Study in Vall Fosca, Catalan Pyrenees, Iberian Peninsula. *Ecol. Soc.* **17**:29. [11]

Calvet-Mir, L., E. Gómez-Bagetthun, and V. Reyes-García. 2012b. Beyond Food Production: Ecosystem Services Provided by Home Gardens: A Case Study in Vall Fosca, Catalan Pyrenees, Northeastern Spain. *Ecol. Econ.* **74**:153–160. [11]

Carlos, E. J., M. T. Garcia-Conesa, and F. A. Tomas-Barberan. 2007. Nutraceuticals: Facts and Fiction. *Phytochemistry* **68**:2986–3008. [11]

Chase Smith, R., M. Benavides, M. Pariona, and M. Tuesta. 2013. Mapping the Past and the Future: Geomatics and Indigenous Territories in the Peruvian Amazon. *Hum. Organ.* **62**:357–368. [11]

Coomes, O. T., S. J. McGuire, E. Garine, et al. 2015. Farmer Seed Networks Make a Limited Contribution to Agriculture? Four Common Misconceptions. *Food Pol.* **56**:41–50. [02, 11, 13]

Cruz-Garcia, G. S., and P. L. Howard. 2013. I Used to Be Ashamed: The Influence of an Educational Program on Tribal and Non-Tribal Children's Knowledge and Valuation of Wild Food Plants. *Learn. Individ. Differ.* **27**:234–240. [11]

Diener, E., and M. E. P. Seligman. 2004. Beyond Money: Toward and Economy of Well-Being. *Psychol. Sci. Public Interest* **5**:1–31. [11]

Dillard, C. J., and J. B. German. 2000. Phytochemicals: Nutraceuticals and Human Health. *J. Sci. Food Agric.* **80**:1744–1756. [11]

Dressler, W. W., and J. R. Bindon. 2000. The Health Consequences of Cultural Consonance: Cultural Dimensions of Lifestyle, Social Support, and Arterial Blood Pressure in an African American Community. *Am. Anthropol.* **102**:244–260. [11]

Eddleston, M., L. Karalliedde, N. Buckley, et al. 2002. Pesticide Poisoning in the Developing World: A Minimum Pesticides List. *Lancet* **360**:1163–1167. [11]

FAO. 1996. Rome Declaration on World Food Security and World Food Summit Plan of Action. In: World Food Summit, November 13–17, 1996. Rome: FAO. [09, 11]

———. 1999a. Background Paper 1: Agricultural Biodiversity, Multifunctional Character of Agriculture and Land Conference, Sept. 1999. Maastricht: FAO. [01, 08, 09, 11]

Friedmann, H., and P. McMichael. 1989. Agriculture and the State System: The Rise and Decline of National Agricultures, 1870 to the Present. *Sociol. Ruralis* **29**:93–117. [11]

Frison, E. A., J. Cherfas, and T. Hodgkin. 2011. Agricultural Biodiversity Is Essential for a Sustainable Improvement in Food and Nutrition Security. *Sustainability* **3**:238–253. [11]

Frison, E. A., I. F. Smith, T. Johns, J. Cherfas, and P. B. Eyzaguirre. 2006b. Agricultural Biodiversity, Nutrition, and Health: Making a Difference to Hunger and Nutrition in the Developing World. *Food Nutr. Bull.* **27**:167–179. [11]

Gatto, E., A. Marino, and G. Signorino. 2013. Biodiversity and Risk Management in Agriculture: What Do We Learn from Cap Reforms? A Farm-Level Analysis. In: Proc. 53rd ERSA Congress on Regional Integration: Europe, the Mediterranean and the World Economy. Palermo: European Regional Science Association. [11]

Greenberg, L. 2003. Women in the Garden and Kitchen: The Role of Cuisine in the Conservation of Traditional House Lots among Yucatec Mayan Immigrants. In: Women and Plants: Gender Relations in Biodiversity Management and Conservation, ed. P. L. Howard, pp. 51–65. London: Zed Books. [11]

Hadley, C., and C. L. Patil. 2006. Food Insecurity in Rural Tanzania Is Associated with Maternal Anxiety and Depression. *Am. J. Hum. Biol.* **18**:359–368. [11]

Hardon-Baars, A. 2000. The Role of Agrobiodiversity in Farm-Household Livelihood and Food Security: A Conceptual Analysis. In: Encouraging Diversity, ed. C. Almekinders, pp. 31–35. London: Intermediate Technology Publications Ltd. [11]

Haselmair, R., H. Pirker, E. Kuhn, and C. R. Vogl. 2014. Personal Networks: A Tool for Gaining Insight into the Transmission of Knowledge About Food and Medicinal Plants among Tyrolean (Austrian) Migrants in Australia, Brazil and Peru. *J. Ethnobiol. Ethnomed.* **10**:1. [11]

Heinrich, M., M. Leonti, S. Nebel, and W. Peschel. 2005. Local Food—Nutraceuticals: An Example of a Multidisciplinary Research Project on Local Knowledge. *J. Physiol. Pharmacol.* **56(Suppl. 1)**:5–22. [11]

Howard, P. L. 2006. Gender and Social Dynamics in Swidden and Homegardens in Latin America. In: Tropical Homegardens: A Time-Tested Example of Sustainable Agroforestry, ed. B. M. Kumar and P. K. R. Nair, pp. 1–24. Heidelberg: Springer. [11]

Jaenicke, H., and D. Virchow. 2013. Entry Points into a Nutrition-Sensitive Agriculture. *Food Secur.* **5**:679–692. [11]

Johns, T., and P. B. Eyzaguirre. 2006. Linking Biodiversity, Diet and Health in Policy and Practice. *Proc. Nutr. Soc.* **65**:182–189. [11]

Johns, T., B. Powell, P. Maundu, and P. B. Eyzaguirre. 2013. Agricultural Biodiversity as a Link between Traditional Food Systems and Contemporary Development, Social Integrity and Ecological Health. *J. Sci. Food Agric.* **93**:3433–3442. [09, 10, 11, 15]

Jones, A. D., A. Shrinivas, and R. Bezner-Kerr. 2014. Farm Production Diversity Is Associated with Greater Household Dietary Diversity in Malawi: Findings from Nationally Representative Data. *Food Pol.* **46**:1–12. [11]

Kahane, R., T. Hodgkin, H. Jaenicke, et al. 2013. Agrobiodiversity for Food Security, Health and Income. *Agronom. Sustain. Devel.* **33**:671–693. [11, 13]

Kawa, N. C., C. McCarty, and C. R. Clement. 2013. Manioc Varietal Diversity, Social Networks, and Distribution Constraints in Rural Amazonia. *Curr. Anthropol.* **54**:764–770. [08, 11]

Khoury, C. K., A. D. Bjorkman, H. Dempewolf, et al. 2014b. Increasing Homogeneity in Global Food Supplies and the Implications for Food Security. *PNAS* **111**:4001–4006. [08, 09, 10, 11, 14]

Kirmayer, L. J., G. M. Brass, and C. L. Tait. 2000. The Mental Health of Aboriginal Peoples: Transformations of Identity and Community. *Can. J. Psychiatry* **45**:607–616. [11]

Kral, M. J., L. Idlout, J. B. Minore, R. J. Dyck, and L. J. Kirmayer. 2011. Unikkaartuit: Meanings of Well-Being, Unhappiness, Health, and Community Change among Inuit in Nunavut, Canada. *Am. J. Community Psychol.* **48**:426–438. [11]

Kuhnlein, H. V., B. Erasmus, and B. Spigelski. 2009. Indigenous Peoples' Food Systems. Rome: Food and Agricultural Organization of the United Nations. [11]

Kuhnlein, H. V., B. Erasmus, D. Spigelski, and B. Burlingame, eds. 2013. Indigenous Peoples' Food Sustems and Well-Being: Interventions and Policies for Healthy Communities. Rome: FAO/CINE. [11]

Kuhnlein, H. V., R. Soueida, and O. Receveur. 1996. Dietary Nutrient Profiles of Canadian Baffin Island Inuit Differ by Food Source, Season, and Age. *Journal of the American Diet Association* **96**:155–162. [11]

Lang, T., and M. Heasman. 2004. Food Wars: The Global Battle for Mouths, Minds and Markets. London: Earthscan. [11]

Litt, J. S., M.-J. Soobader, M. S. Turbin, et al. 2011. The Influence of Social Involvement, Neighborhood Aesthetics, and Community Garden Participation on Fruit and Vegetable Consumption. *Am. J. Public Health* **101**:1466–1473. [11]

López-García, D., and G. I. Guzmán-Casado. 2013. Si la Tierra Tiene Sazón:el Conocimiento Tradicional Campesino Como Movilizador de Procesos de Transición Agroecológica. *Agroecologia* **7**:7–20. [11]

Mathew, A. G., R. Cissell, and S. Liamthong. 2007. Antibiotic Resistance in Bacteria Associated with Food Animals: A United States Perspective of Livestock Production. *Foodborne Pathog. Dis.* **4**:115–133. [11]

McMichael, P. 2009. A Food Regime Analysis of the World Food Crisis. *Agricult. Human Values* **26**:281–295. [11]

Milligan, C., A. Gatrell, and A. Bingley. 2004. Cultivating Health: Therapeutic Landscapes and Older People in Northern England. *Soc. Sci. Med.* **58**:1781–1793. [11]

Mossakowski, K. N. 2003. Coping with Perceived Discrimination: Does Ethnic Identity Protect Mental Health? *J. Health Soc. Behav.* **44**:318–331. [11]

Noack, A.-L., and N. R. M. Pouw. 2015. A Blind Spot in Food and Nutrition Security: Where Culture and Social Change Shape the Local Food Plate. *Agricult. Human Values* **32**:169–182. [11]

Ostrom, E. 1990. Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge: Cambridge University Press. [11]

Otero, G. 2012. The Neoliberal Food Regime in Latin America: State, Agribusiness Transnational Corporations and Biotechnology. *Rev. Can. Etudes Dev.* **33**:282–294. [11]

Perkins, J. M., S. V. Subramanian, and N. A. Christakis. 2015. Social Networks and Health: A Systematic Review of Sociocentric Network Studies in Low- and Middle-Income Countries. *Soc. Sci. Med.* **125**:60–78. [11]

Pieroni, A., S. Nebel, R. F. Santoro, and M. Heinrich. 2005. Food for Two Seasons: Culinary Uses of Non-Cultivated Local Vegetables and Mushrooms in a South Italian Village. *Int. J. Food Sci. Nutr.* **56**:245–272. [11]

Pinstrup-Andersen, P. 2009. Food Security: Definition and Measurement. *Food Secur.* **1**:5–7. [11]

Powell, B., S. H. Thilsted, A. Ickowitz, et al. 2015. Improving Diets with Wild and Cultivated Biodiversity from across the Landscape. *Food Secur.* **7**:535–554. [09, 10, 11]

Ravera, F., U. Pascual, A. Drucker, et al. 2019. Gendered agrobiodiversity management and everyday adaptation practices in two marginal rural areas of India. *Agricul. Human Values*, in press. [11]

Renting, H., and H. Wiskerke. 2010. New Emerging Roles for Public Institutions and Civil Society in the Promotion of Sustainable Local Agro-Food Systems. In: Proc. 9th European IFSA Symposium: Transitions Towards Sustainable Agriculture from Farmers to Agro-Food Systems, ed. I. Darnhofer and M. Grötzer, pp. 1902–1912. Vienna: Vienna. [11]

Reyes-Garcia, V., J. Luis Molina, L. Calvet-Mir, et al. 2013. *Tertius Gaudens*: Germplasm Exchange Networks and Agroecological Knowledge among Home Gardeners in the Iberian Peninsula. *J. Ethnobiol. Ethnomed.* **9**:53. [11]

Reyes-García, V., G. Menendez-Baceta, L. Aceituno-Mata, et al. 2015. From Famine Foods to Delicatessen: Interpreting Trends in the Consumption and Gathering of Wild Edible Plants through Their Connection to Cultural Ecosystem Services. *Ecol. Econ.* **12**:303–311. [08, 11]

Ricciardi, V. 2015. Social Seed Networks: Identifying Central Farmers for Equitable Seed Access. *Agric. Syst.* **139**:110–121. [11]

Ruel, M. T. 2003. Operationalizing Dietary Diversity: A Review of Measurement Issues and Research Priorities. *J. Nutr.* **133**:3911S–3926S. [11]

Schmidhuber, J., and F. N. Tubiello. 2007. Global Food Security under Climate Change. *PNAS* **104**:19703–19708. [11]

Schwartz, S. J., J. B. Unger, B. L. Zamboanga, and J. Szapocznik. 2010. Rethinking the Concept of Acculturation Implications for Theory and Research. *Am. Psychol.* **65**:237–251. [11]

Shea, K. M. 2003. Antibiotic Resistance: What Is the Impact of Agricultural Uses of Antibiotics on Children's Health? *Pediatrics* **112**:253–258. [11]

Shillington, L. 2008. Being(S) in Relation at Home: Socio-Natures of Patio Gardens in Managua, Nicaragua. *Soc. Cult. Geogr.* **9**:755–776. [11]

Smith, K. P., and N. A. Christakis. 2008. Social Networks and Health. *Annu. Rev. Sociol.* **34**:405–429. [11]

Thrupp, L. A. 2000. Linking Agricultural Biodiversity and Food Security: The Valuable Role of Agrobiodiversity for Sustainable Agriculture. *Int. Aff.* **76**:265–281. [11, 13, 15]

Tilman, D. 1999. Global Environmental Impacts of Agricultural Expansion: The Need for Sustainable and Efficient Practices. *PNAS* **96**:5995–6000. [09, 11]

Uchino, B. N. 2009. Understanding the Links between Social Support and Physical Health: A Life-Span Perspective with Emphasis on the Separability of Perceived and Received Support. *Perspect. Psychol. Sci.* **4**:236–255. [11]

Valente, T. W. 2010. Social Networks and Health : Models, Methods, and Applications. New York: Oxford University Press. [11]

Vincenti, B., P. Eyzaguirre, and T. Johns. 2008. The Nutritional Role of Forest Plant Foods for Rural Communities. In: Human Health and Forests: A Global Overview of Issues, Practice and Policy, ed. C. J. P. Colfer, pp. 63–93. London: Earthscan. [11]

Weisenburger, D. D. 1993. Human Health-Effects of Agrichemical Use. *Hum. Pathol.* **24**:571–576. [11]

Whitaker, R. C., S. M. Phillips, and S. M. Orzol. 2006. Food Insecurity and the Risks of Depression and Anxiety in Mothers and Behavior Problems in Their Preschool-Aged Children. *Pediatrics* **118**:E859–E868. [11]

WHO. 1946. Preamble to the Constitution of the World Health Organization as Adopted by the International Health Conference, New York, 19-22 June, 1946. In: Official Records of the World Health Organization, p. 100. New York: World Health Organization. [11]

Wilkinson, R. G. 2000. Mind the Gap: Hierarchies, Health, and Human Evolution. London: Weidenfeld & Nicolson. [11]

Wolff, F. 2004. Legal Factors Driving Agrobiodiversity Loss. *Environ. Law Network Int.* **1**:1–11. [11]

Zimmerer, K. S. 2003b. Just Small Potatoes (and Ulluco)? The Use of Seed-Size Variation in Native Commercialized Agriculture and Agrobiodiversity Conservation among Peruvian Farmers. *Agricult. Human Values* **20**:107–123. [11]

———. 2010. Biological Diversity in Agriculture and Global Change. *Annu. Rev. Environ. Resour.* **35**:137–166. [06. 08, 11, 13, 14]

Zimmerer, K. S., J. A. Carney, and S. J. Vanek. 2015. Sustainable Smallholder Intensification in Global Change? Pivotal Spatial Interactions, Gendered Livelihoods, and Agrobiodiversity. *Curr. Opin. Environ. Sustain.* **14**:49–60. [04, 06, 08, 11, 13, 14, 15]